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CLAIMS

What is claimed is:

1. A fuel injector comprising a valve member which is engageable with a valve seating to control fuel delivery from the injector, an actuator arrangement and a hydraulic amplifier arrangement for transmitting movement of the actuator arrangement to the valve member, the hydraulic amplifier arrangement comprising a piston member and a control chamber for fluid, whereby the actuator arrangement is cooperable with the piston member so as to apply a retracting force to the piston member, the amplifier arrangement being arranged such that, upon application of an initial retracting force to the piston member, the valve member is caused to move with the piston member away from the valve seating, movement of the valve member being decoupled from the piston member following initial movement of the valve member away from the seating such that further movement of the valve member is transmitted from the actuator arrangement to the valve member through fluid within the control chamber, the amplifier arrangement thereby providing a variable amplification of movement of the actuator arrangement to the valve member.

2. A fuel injector as claimed in Claim 1, comprising mechanical coupling means for coupling movement of the piston member to the valve member upon application of the initial retracting force.

3. A fuel injector as claimed in Claim 1, wherein the actuator arrangement includes a stack of piezoelectric elements, the piezoelectric elements being cooperable with the piston member so as to apply the retracting force to the piston member upon the axial length of the piezoelectric stack being reduced.

4. A fuel injector as claimed in Claim 1, wherein the control chamber is defined, in part, by a piston bore provided in the piston member.

5. A fuel injector as claimed in Claim 1, comprising a further chamber, whereby upon opening movement of the valve member fuel flows from the control chamber to the further chamber at a relatively low rate.

6. A fuel injector as claimed in Claim 5, wherein the injector further comprises a first arrangement for substantially preventing closing movement of the valve member from being damped.

7. A fuel injector as claimed in Claim 6, wherein the first arrangement takes the form of a valve arrangement which is operable between a closed position, in which a substantially fluid tight seal is provided between the control chamber and the further chamber, and an open position in which a flow path for fuel provides communication between the control chamber and the further chamber.

8. A fuel injector as claimed in Claim 7, wherein the valve arrangement includes an annular valve member which is engageable with a further seating, and wherein the flow path for fuel is defined, in part, between the annular valve member and the further seating.

9. A fuel injector as claimed in Claim 8, wherein the further seating is defined by a surface of the valve member, the annular valve member being engageable with the further seating to control opening and closing of the flow path for fuel.

10. A fuel injector as claimed in Claim 6, wherein the first arrangement takes the form of a valve arrangement which is operable between a seated position in which a restricted flow path is defined between the control chamber and the further chamber and an unseated position in which a relatively unrestricted flow path for fuel is defined between the control chamber and the further chamber.

11. A fuel injector as claimed in Claim 10, wherein the valve arrangement includes an annular valve member.

12. A fuel injector as claimed in Claim 10, wherein the annular valve member defines, in part, a restricted flow path which serves to restrict the rate of flow

of fuel from the control chamber during opening movement of the valve member, thereby to cause opening movement of the valve member to be damped.

13. A fuel injector as claimed in Claim 12, wherein the annular valve member has an outer surface provided with a screw thread formation which defines, in part, the restricted flow path.

14. A fuel injector as claimed in Claim 5, further comprising a damping arrangement for damping opening movement of the valve member.

15. A fuel injector as claimed in Claim 14, wherein the damping arrangement includes a restricted passage provided in the valve member, one end of which communicates with the control chamber and the other end of which communicates with the further chamber, whereby upon opening movement of the valve member fuel flows from the control chamber to the further chamber at a relatively low rate.

16. A fuel injector as claimed in Claim 1, comprising a nozzle body provided with a nozzle body bore within which the valve member is movable, the nozzle body being provided with a projection which is received, in part, within a sleeve member within which the piston member slides.

17. A fuel injector as claimed in Claim 16, wherein the piston member forms a substantially fluid tight seal within the sleeve member.

18. A fuel injector as claimed in Claim 1, wherein the valve member is shaped to include a region of enlarged diameter, the piston member being shaped to defined a further surface which is engageable with the enlarged region of the valve member so as to couple movement of the piston member and the valve member upon application of the initial retracting force, movement of the piston member and the valve member being decoupled following initial movement of the valve member away from its seating.

19. A fuel injector as claimed in Claim 1, wherein the mechanical coupling arrangement takes the form of a substantially C-shaped spring received partially within a first groove provided on the surface of the valve member and partially within a corresponding second groove provided on the piston member such that, upon application of the initial retracting force to the piston member, the spring serves to couple movement of the piston member to the valve member.

20. A fuel injector as claimed in Claim 19, wherein the spring is arranged such that, following initial movement of the valve member away from the valve seating, the spring is able to ride within the corresponding second groove provided on the piston member, thereby permitting relative movement between the piston member and the valve member.

21. A fuel injector as claimed in Claim 4, comprising a nozzle body, wherein the further chamber is defined, in part, by a recess provided in an end surface of the nozzle body.

22. A fuel injector as claimed in Claim 3, wherein the stack of piezoelectric elements has an end member associated therewith, the end member cooperating with the piston member so as to transmit movement to the piston member upon the axial length of the piezoelectric element being varied.

23. A fuel injector as claimed in Claim 22, wherein the piston member is provided with resilient bias means which serve to urge the piston member and the valve member towards a position in which the valve member is seated.

24. A fuel injector as claimed in Claim 22, wherein the end member and the piston member are provided with a second arrangement for preventing relative angular movement therebetween.

25. A fuel injector as claimed in Claim 22, wherein the end member is provided with a spherical joint to ensure the piston member is substantially axially aligned with a nozzle body of the injector.

26. A fuel injector comprising:

a valve member which is engageable with a valve seating to control fuel delivery from the injector;

a hydraulic amplifier arrangement coupled to the valve member via a piston member and a control chamber; and,

an actuator arrangement coupled to the piston member, wherein the hydraulic amplifier arrangement and the actuator arrangement are adapted to apply an initial retracting force to the piston member to move the valve member away from the valve seating and to apply a second retracting force to the piston member thereafter.

27. A fuel injector, as set forth in claim 26, wherein the second retracting force is less than the initial retracting force.

28. A method for operating a fuel injector for delivering fuel from the injector having a valve member which is engageable with a valve seating to control fuel delivery from the injector; a hydraulic amplifier arrangement coupled to the valve member via a piston member and a control chamber, and an actuator arrangement coupled to the piston member, the method comprising the steps of:

applying an initial retracting force to the piston member to move the valve member away from the valve seating; and,

applying a second retracting force to the piston member after initial movement of the valve member.